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(54) Method and apparatus for bending and tempering a glass sheet.

(57) The invention relates to a method and apparatus for bending and tempering a glass sheet. A glass sheet is supported by one and the same ring mould (3) throughout all its working operations. Following the preheating of a glass sheet from a temperature of about 500°C, its heating to a final bending and tempering temperature is effected at a high output and rate of speed. For example, on 4 mm thick glass, this final heating is performed within a period of time of 15-25 s. Therefore, the temperature of bending station is 800-1000°C. Since rapidly heating glass bends quickly, the bending flexure or temperature of glass is monitored and the glass is advanced to tempering as soon as a predetermined bending flexure or temperature is reached.

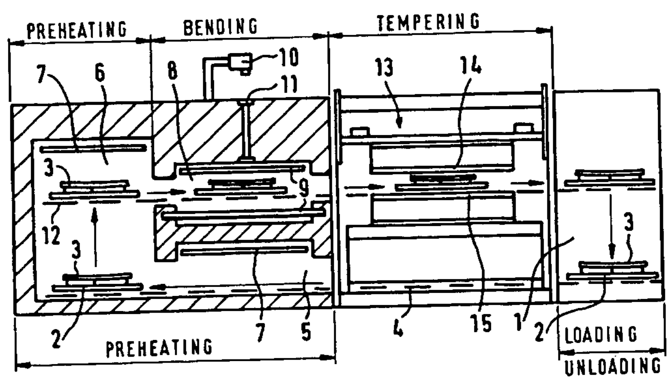

Fig. 1

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(3. 10/3.6/3.3. 1)

The present invention relates to amethod for bending and tempering a glass sheet, in which method a glass sheet supported by a ring mould is heated to a softening temperature, a glass sheet is allowed to bend gravitationally and a bent glass sheet is advanced to tempering.

The invention relates also to an apparatus for bending and tempering a glass sheet, said apparatus comprising a ring mould for supporting a glass sheet at various stages of handling, a preheating station, and a quenching station.

The invention is particularly well suited for bending relatively simple glass shapes which can be bent gravitationally by using a ring mould. Most of the automotive side windows and backlights are such simple shapes or forms that can be bent by using a methos and apparatus of the invention. For essentially the same purpose there is a prior known method, wherein a piece of hemothermal glass is dropped onto a ring mould and the piece of glass assumes its proper form by virtue of inertial force and the shape of a ring mould. This prior known method offers the advantages of high capacity and reliability but its drawbacks include a high price, a rather long form replacement time (4-5 h), marks caused by dropping on the glass border areas, and the high price of tools required by individual pieces of glass.

On the other hand, there are known single furnaces operating on the ring mould principle, wherein the glass is only heated from above and the glass bends to its shape or form whose bending depth is determined by adjusting the heating time. An advantage offered by single furnace is a simple construction and a low price but there are also drawbacks, including a low capacity, a relatively high minimum thickness (typically 5 mm, sometimes 4 mm), simple bending shapes and fairly good bending accuracy (as the bending depth is only controlled by means of heating time).

An object of the invention is to provide an improved method and apparatus, capable of offering the following benefits:

- economical price in view of capacity
- a reachable glass thickness is substantially below 4 mm, typically a 3,2 mm minimum thickness or therebelow
- compact size of the apparatus
- low tooling costs (e.g., only four ring moulds are required for a glass pattern)
- a short glass-pattern replacement time (typically less than 0,5 h).

This object of the invention is achieved on the basis of the characterizing features set forth in the annexed claims.

One embodiment of the invention will now be described in more detail with reference made to the accompanying drawing, in which

fig. 1 shows schematically a lengthwise vertical section through a furnace of the invention and

fig. 2 shows schematically a lengthwise horizontal section through the same furnace.

Fig. 3 shows a detail in a bending station 8.

In a loading station 1 a glass sheet to be bent is placed on top of a ring mould 3. The ring mould 3 is advanced upon a carriage 2 along a lower horizontal track 4 into a preheating station 5, fitted with resistances 7 for heating a glass sheet from above by the application of radiation heat. Thereafter, said carriage 2 along with its mould 3 and glass sheet is shifted to below a preheating station 6 and is lifted by means of a hoist into said preheating station 6, wherein the heating is continued by means of resistances 7. As known in the art, the preheating can be effected at a relatively rapid rate since heat transfers effectively to cold glass. In preheating, a glass sheet typically reaches a temperature of about 500°C. Naturally, the final temperature of preheating can fluctuate considerably one way or the other. The preheated glass along with its ring mould 3 is advanced into a bending station 8, which at the same time serves as an effective heating chamber having a temperature of appr. 900°C. The temperature of heating and bending chamber 8 can typically fluctuate within the range of 800-1000°C. Said chamber 8 is provided with powerful resistances 9 for heating a glass sheet so quickly that a piece of 4 mm glass heats from 500°C within about 15-20 seconds up to a tempering temperature of 600-630°C, typically 615-620°C. During this rapid heating the glass is simultaneously allowed to bend. Thus, e.g. with 4 mm glass, the temperature increase rate is preferably about 6-8°C/s, i.e. generally about 24-32°C/mm/s. In order to achieve the object of the invention, the temperature increase rate should be at least appr. 15°C/mm/s.

The glass temperature is monitored by means of a pyrometer and/or the bending flexure by means of an optical apomecometer device 10. Therefore, the heat insulation of the furnace ceiling is provided with an observation window 11. When pyrometer and/or flexure measuring device 10 detects that a predetermined glass temperature and/or bending flexure has been reached, the glass is carried as quickly as possible to tempering. The passage from bending station 8 to a tempering station 13 is effected on the same ring mould 3 along a track 12. In tempering station 13, both sides of a glass sheet are subjected to the action of cooling air jets. This can be accomplished by using upper and lower manifolds 14 and 15, whose ends can be either on a straight line or can be set according to an anticipated, compromised bending

form. From tempering station 13 the glass and its mould 3 are transferred into an unloading station, wherein the tempered glass is removed from ring mould 3. This is followed by placing the next piece of glass on top of the ring mould and the glass, together with its ring mould, is advanced into the preheating station.

Ring mould 3 is supported on carriage 2 from outside and it is coated with a fibrous coating suitable for glass bending and tempering.

The movements of carriage 2 along tracks 4 and 12 are produced e.g. by means of a system described in US Patent publication 4 497 645 by using carriages mounted on wheels rotatable from outside the furnace.

The bending station 8 serving as a power heating chamber is the heart of an apparatus of the invention. A novel feature therein is high-speed heating facilitated by a high temperature, appr. 900°C. The bending of glass can be effected without the application of heat by means of a ring mould to a desired shape. This applies to simple glass shapes but, as the shape reaches a higher degree of complexity, the glass thickness decreases and the glass size increases, there will be more and more difficulties in producing a desired shape or form. Close control of the glass temperature and/or degree of bending and a possibility of moving the glass quickly to tempering make sure, however, that a method and apparatus of the invention are capable of readily and controllably bending flexural forms that are conventional in automotive backlights and side windows.

A method of the invention facilitates particularly the bending and tempering of thin (3-4 mm) pieces of glass as bending does not begin until the tempering temperature is just exceeded; as soon as a desired shape is obtained, the glass can be advanced directly to tempering. In the cases of lower-temperature furnaces this is not possible, since the central glass area has already had enough time to sag or bend further than a desired shape by the time the tempering temperature is reached.

When using a ring mould for supporting a piece of glass throughout the heating operation, the result will be that the border or edge areas of glass remain colder than the rest of the glass. The reason for this is that, by virtue of its mass and thermal capacity, a ring mould shall remain colder than glass and, thus, it receives heat from glass. If a piece of glass is to be tempered, the entire glass must be thoroughly heated to above the tempering temperature and, thus, the central glass areas will become unnecessarily hot. This, in turn, leads to uncontrollable over-bending of the central glass areas.

If the effect of ring mould 3 on a slower heating rate in the border area of a glass sheet cannot be eliminated or compensated by a further heating of the border area, the glass will be heated over its central area to 10-20°C unnecessarily high temperature in order to temper the border area as well (or just to keep the glass intact). Considering the common rule that the bending rate of glass doubles as the glass temperature increases by 8°C, it is possible to understand the problem caused by the cooling effect of a ring mould.

In order to eliminate this problem, the invention suggests that the heating of a glass sheet in bending station 8 be intensified by using forced convection at least in the glass sheet border areas supported by ring mould 3. This is illustrated in fig. 3.

Thus, the glass border or edge area is heated more to equalize the cooling effect of a ring mould, but no more than that. The objective is to obtain a completely hemothermal piece of glass.

The technical solution is carried out by using compressed air jets which are blasted from tubes 17 and/or 18 fitted adjacent to the border area. From the lower tube 17 the air jets are blown vertically upwards (possibly at a 15° angle) in a manner that the air jet does not hit the glass but the border area and ring mould 3 are heated by a vortex formed by the air jets. Since the demand for supplementary heat is slight, just one of the tubes, e.g. lower tube 17, is probably needed. In practice, the manifold is not a continuous loop but divided into a plurality of individually controlled zones.

Tests have shown that mere radiation heating is not always capable of sufficiently heating the top surface of glass but, instead, the bottom side heats more even though the bottom side would not be actually heated at all. This can be compensated by utilizing convection blasting if necessary over the entire surface area of a glass sheet in view of compensating for the heating of either top or bottom surface.

As already pointed out, the bent piece of glass heated to a tempering temperature is advanced as quickly as possible to tempering. This is important since, once outside a furnace, the 4 mm glass cools prior to tempering at a rate of appr. 5°C/s. Every "wasted" second results in unnecessary over-heating of glass by 5°C. Therefore, the quenching blast should already be switched on and the nozzles should be in a proper position when the glass is brought to tempering. If tempering of all glass shapes cannot be performed by a single manifold or nozzle system, said manifolds 14, 15 can be made replaceable. In the simplest of embodiments, said manifolds or nozzle systems 14, 15 comprise folded and perforated plates. For example, four different manifolds (perforated plates) folded to various shapes will be sufficient to cover the entire area. Naturally, it would also be possible to employ an adjustably shaped manifold

(adjustment can be manual).

As described above, an apparatus of the invention is very simple in its technical construction and thus economical in its costs. Nevertheless, in view of its price and size, said apparatus yields a very high production capacity (60-120 loadings/h).

Claims

1. A method for bending and tempering a glass sheet, in which method a glass sheet supported by a ring mould (3) is heated to a softening temperature, a glass sheet is allowed to bend gravitationally, and a bent glass sheet is advanced to tempering, **characterized** in that above the glass temperature of 500°C the heating of a glass sheet to a tempering temperature is effected at such a heating rate that 4 mm glass heats from the temperature of 500°C to a tempering temperature of 600-630°C in less than 28 seconds, preferably within about 15-20 seconds, whereby the temperature increase rate of a glass sheet at least at the glass surface is in average at least appr. 15°C/mm/s, preferably 24-32°C/mm/s.

2. A method as set forth in claim 1, **characterized** in that said temperature increase rate is 24-32°C/mm/s or 6-8°C/s on 4 mm glass.

3. A method as set forth in claim 1 or 2, **characterized** in that the bending flexure or temperature of glass is measured and, upon reaching a predetermined bending flexure or temperature, the glass is advanced to quenching supported by the same ring mould (3).

4. A method as set forth in any of claims 1-3, **characterized** in that prior to passing a glass sheet into a bending station (8), the preheating of glass is effected on two levels, first on a lower level (station 5) and then, after hoisting said ring mould (3), on an upper level (station 6), and that the glass is carried on the same ring mould (3) to bending and tempering.

5. A method as set forth in claim 1 or 2, **characterized** in that in bending station the heating of a glass sheet is intensified by forced convection.

6. A method as set forth in claim 5, **characterized** in that boosted convection is applied at least to the border areas of a glass sheet, which are supported by ring mould (3).

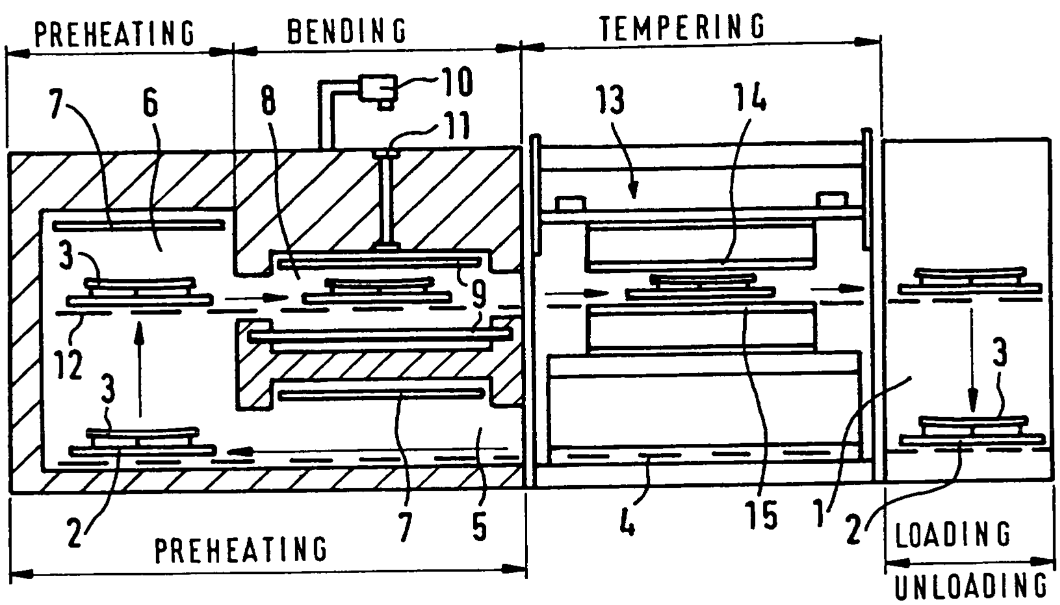
7. A method as set forth in claim 6, **characterized** in that the boosted convection is applied to the border areas of a glass sheet in a manner that the blasting jets are directed past the edge of a glass sheet adjacent to the edge of a glass sheet.

8. An apparatus for bending and tempering a glass sheet, said apparatus comprising a ring mould (3) for supporting a glass sheet in various working operations, a heating station (5, 6), a bending station (8), and a quenching station (13), **characterized** in that
   1) the temperature of bending station is substantially higher than the temperature to which a glass sheet is heated for bending and tempering; and
   2) said bending station (8) is provided with means (10) for measuring the bending flexure or temperature of a glass sheet and these measuring means (10) are adapted to commence the passage of ring mould (3) and a glass sheet supported thereby from bending station (8) into quenching station (13).

9. An apparatus as set forth in claim 8, **characterized** in that the temperature of bending station (8) is at least 100°C, preferably over 200°C, higher than the highest final temperature of a glass sheet to which a glass sheet is heated for tempering.

10. An apparatus as set forth in claim 9, **characterized** in that the temperature of a bending station is about 800-1000°C and the tempering temperature of a glass sheet is about 600-630°C, at which temperature a glass sheet is advanced from bending station (8) into tempering or quenching station (13).

11. An apparatus as set forth in claim 9-10, **characterized** in that preheating stations (5 and 6) are located on two different vertical levels in a manner that one preheating station (5) lies below bending station (8) and the other preheating station (6) lies adjacent to bending station (8).


PREHEATING
BENDING
TEMPERING
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15
2
PREHEATING
LOADING
UNLOADING

Fig. 1

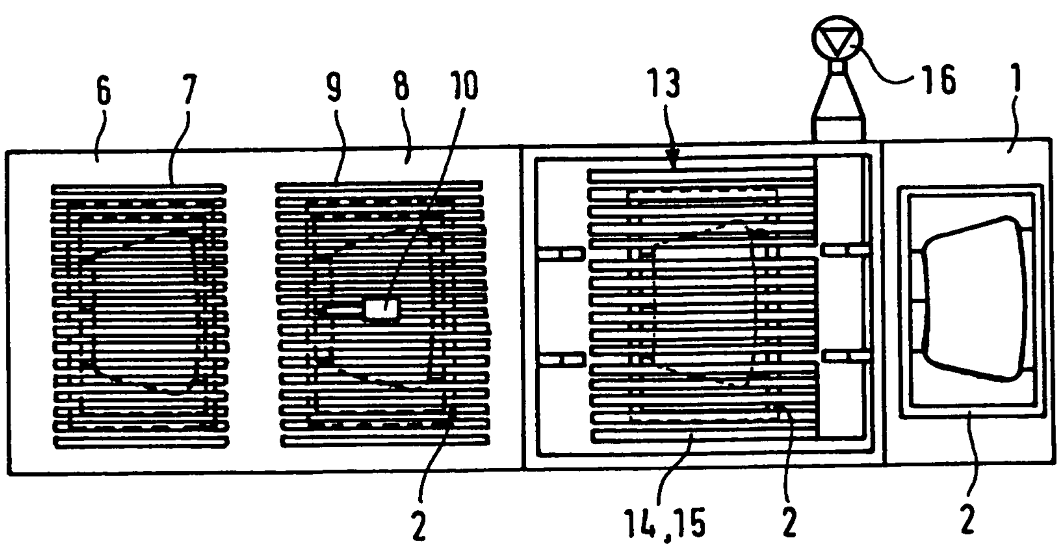
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Fig. 2

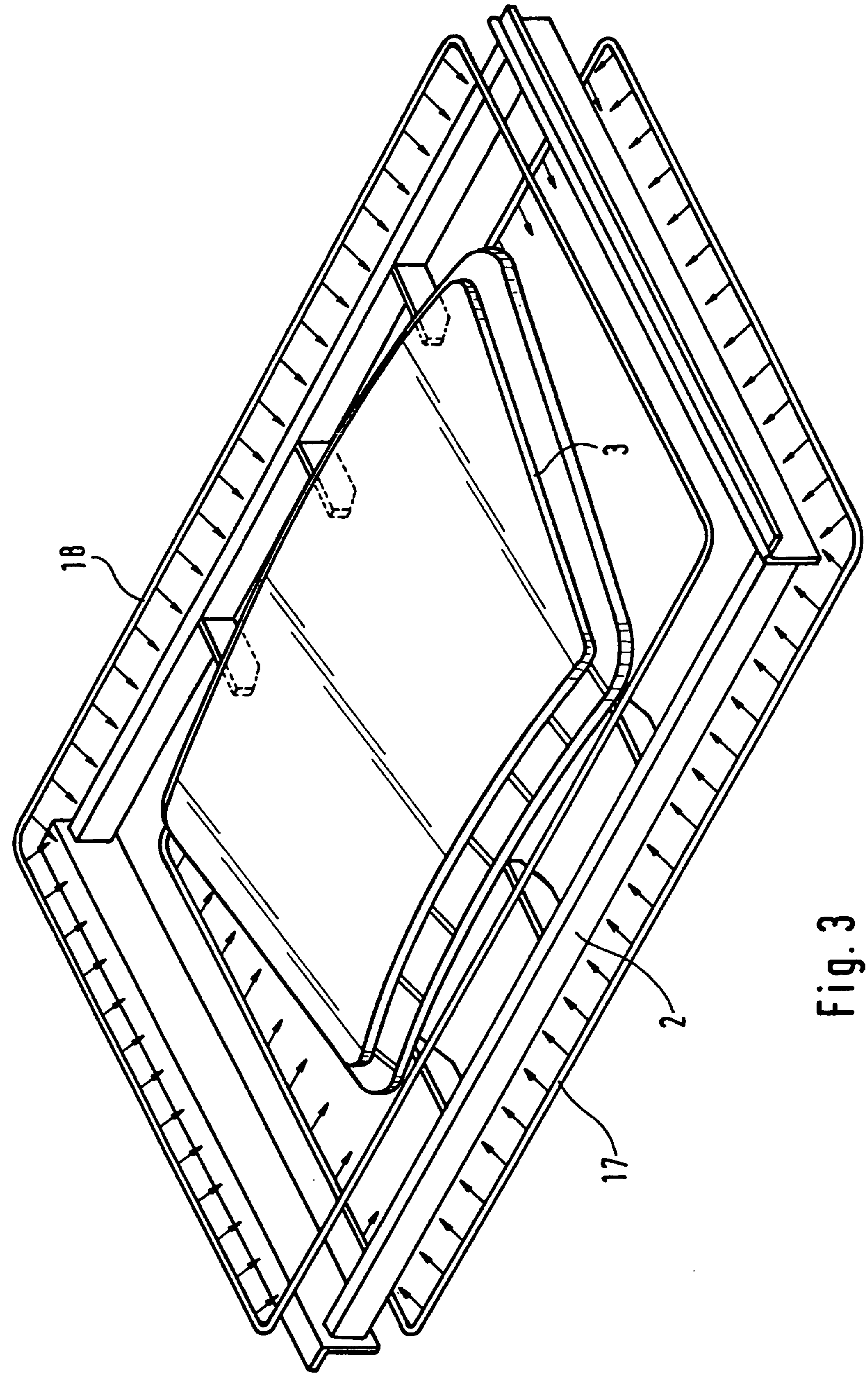

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number

EP 93 10 6922

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 370 313 (TAMGLASS OY) * claims; figures * ---	1-11	C03B23/025 C03B25/08 C03B29/08
A	EP-A-0 233 778 (PILKINGTON BROTHERS) * the whole document * ---	1-11	
A	US-A-3 166 397 (F.R. HOHMANN ET AL) * the whole document * ---	1-11	
A D	EP-A-0 132 701 (O/Y KYRO A/B TAMGLASS) * claims; figures * & US-A-4 497 645 -----	1-11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C03B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	23 AUGUST 1993	KUEHNE H.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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O : non-written disclosure
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T : theory or principle underlying the invention
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